
Designing Digital Avionics Systems for Reduced Vulnerability

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A Vulnerability Perspective
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“Effects of Digital Avionics Systems on the Survivability of Modern Tactical Aircraft”,

at the Naval Postgraduate School (NPS) Under the Direction of Distinguished Professor Robert E. Ball, Ph.D.

Why Reduce Avionics Vulnerability?

Three Reasons:

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- To Enhance Flight Safety
-
- To Anticipate and Counter Possible Terrorist Threats
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- To Reduce or Minimize Damage Due to Military Threats

Why Worry About Digital Avionics Systems?

- Modern Aircraft Designs Incorporate Digital Avionics Systems
- Example Systems:
 - Fly-by-wire Flight Control Systems
 - Communications Navigation and Surveillance (CNS) Systems
 - Digital Engine Controls (FADEC)
 - Electronic Flight Information Systems (EFIS)
 - Digital Data Bus Systems
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- Example Aircraft:
 - Boeing 777, Airbus A340, etc.
 - F-22, JSF, etc.

Digital Avionics Systems

- Consist of:
 - “Black Boxes”
 - Wires/Cables
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- Depend on:
 - Supply of Electrical Power
 - Component Integrity
 - Tolerable Environmental Conditions

How Can Digital Avionics Be Damaged/Disabled?

- Loss of Electrical Power
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- Fire/Explosive Effects
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- Electromagnetic Interference (EMI)
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- Electromagnetic Pulse (EMP)

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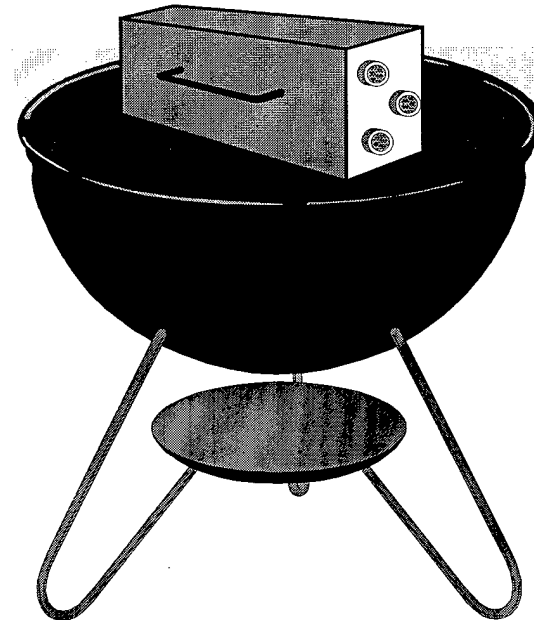


Fire/Explosive Effects

If Aircraft Structural Integrity is Lost
Avionics Are No Longer a Concern

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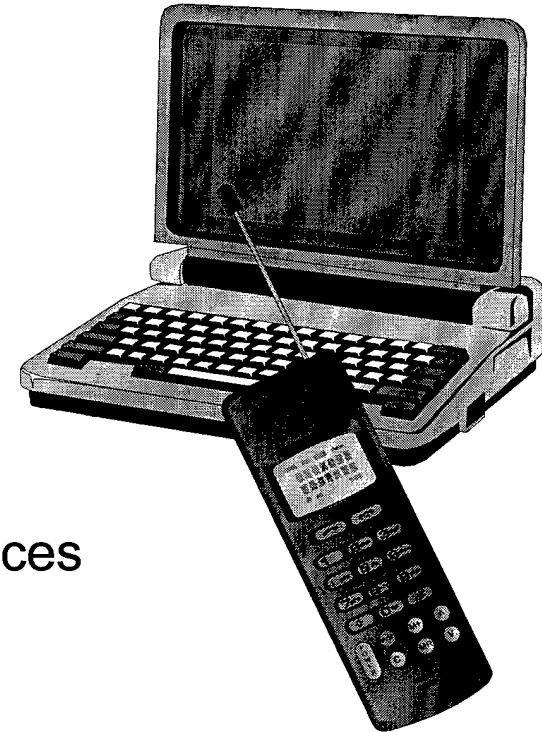
If Aircraft Structural Integrity is Retained
Avionics are Needed



Electromagnetic Interference/Pulse (EMI/EMP)

EMI/EMP Threats:

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- High Intensity Radiated Fields (HIRF)
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- Passenger Electronic Devices (PED)
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- Terrorist/Military Use of Electromagnetic Devices



Is There An EMI Threat?

Excerpt From a Major Airline's In-flight Magazine:

Electronic Equipment: Certain electronic devices - such as AM and FM transmitters and receivers, portable telephones, televisions, video cameras and remote controlled toys - **may interfere with communications and navigation systems on the airplane.**

If Inadvertent EMI is Possible, How Difficult is it to Deliberately Cause EMI?

How Could We Screen Out Such Devices, or Detect Their Use?

Will Future Military Systems Exploit EMI/EMP?

Vulnerability Reduction Techniques Applicable to Avionics

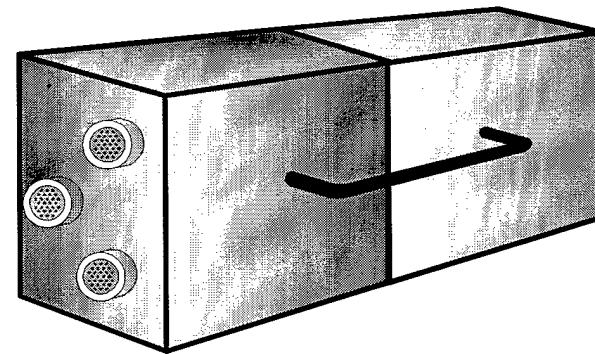
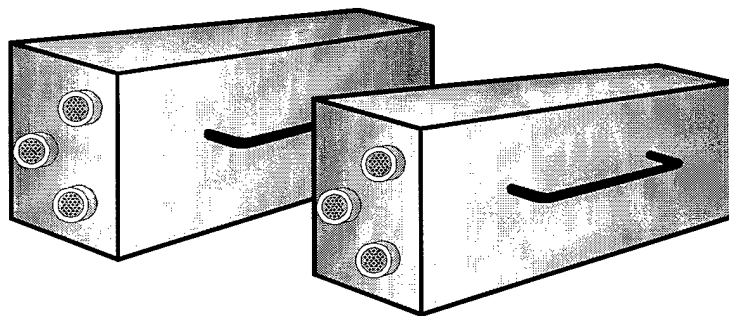
- Component Redundancy (with separation)
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- Component Location
-
- Passive Damage Suppression
-
- Active Damage Suppression
-
- Component Shielding
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- Component Elimination

Component Redundancy With Separation

Goal: Avoid a Single Point Kill by Physical Separation of Redundant Functional Components

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Example: Flight Control Computer



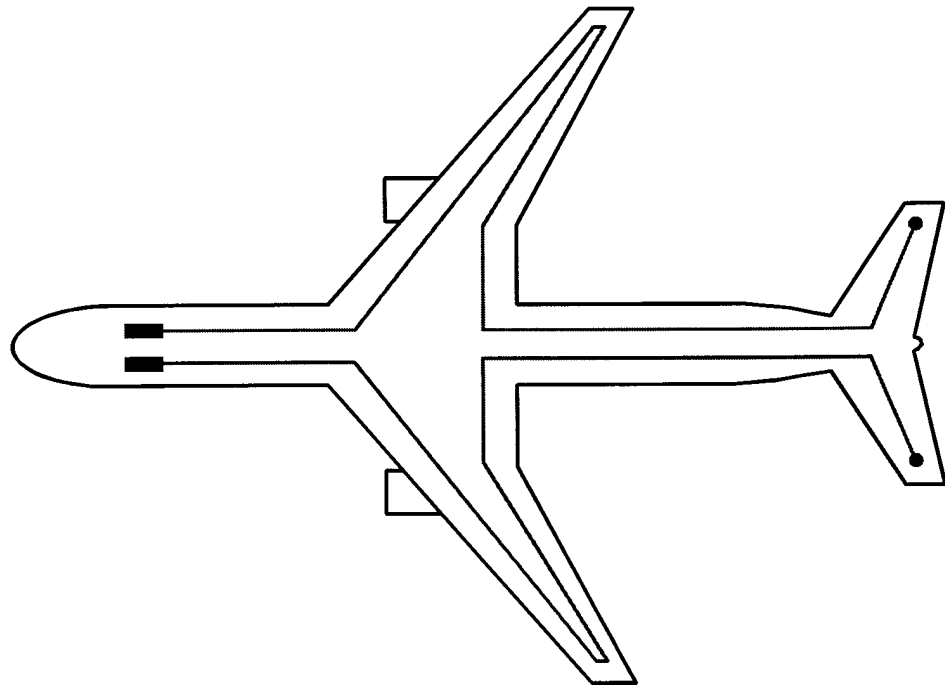
Multiple Physically Separate Units Are Inherently More Survivable Than a Single, Multi-channel Unit

Component Redundancy With Separation

Goal: Avoid a Single Point Kill by Physical Separation of Redundant Functional Components

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Example: Data Bus Wiring



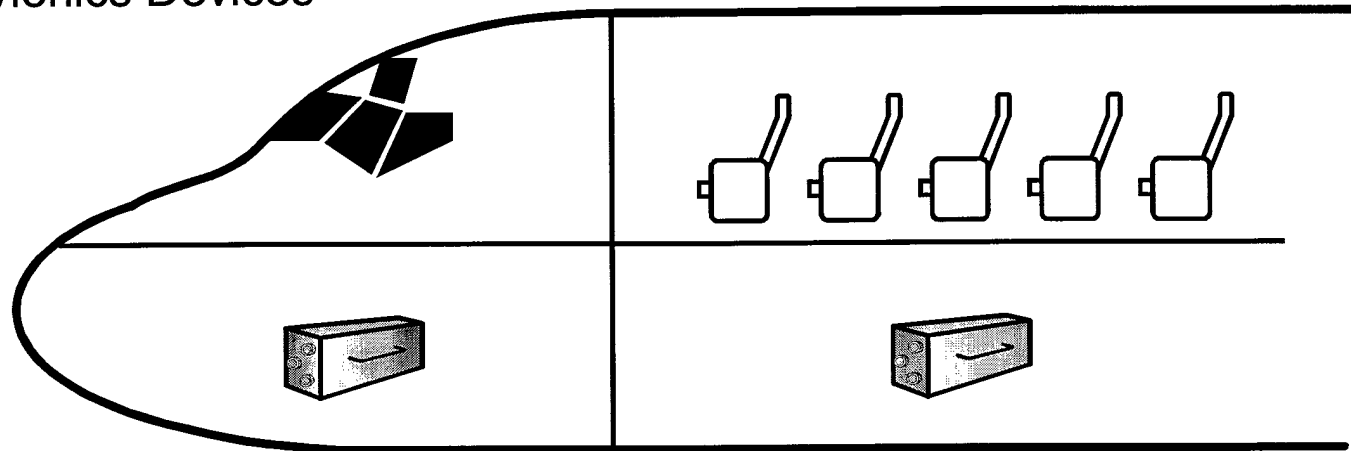
Multiple Data Bus Cables, Routed for Maximum Practical Separation

Component Location

Goal: To Position Components So That a Damage Mechanism Is Less Likely to Kill a Component

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Example: Avionics Devices

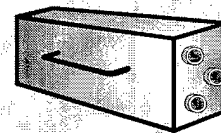
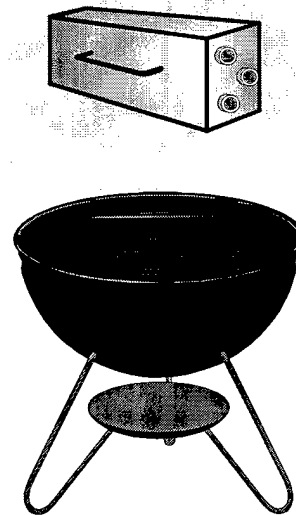


Box A Is Positioned Further Away From Possible Fire/Explosion in Cargo/Baggage or Passenger Compartments

Passive Damage Suppression

Goal: To Either Reduce Damage or Reduce the Effects of Damage

Example: Flight Data Recorder



CNS Avionics



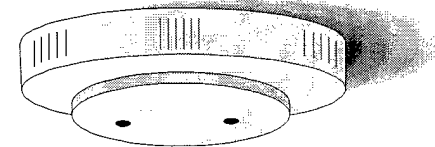
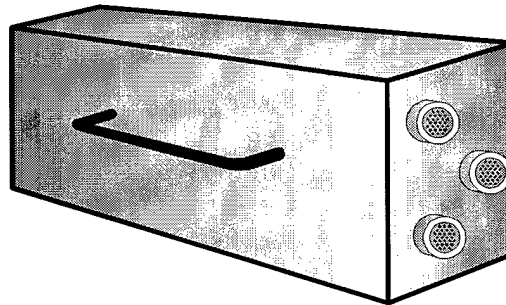
Design Avionics to Tolerate EMI, Fire and Blast Effects to the Extent Practicable

Active Damage Suppression

Goal: To Detect and Counter the Effects of a Damage Process (i.e., fire)

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Example: Fire Detection and Extinguishing System



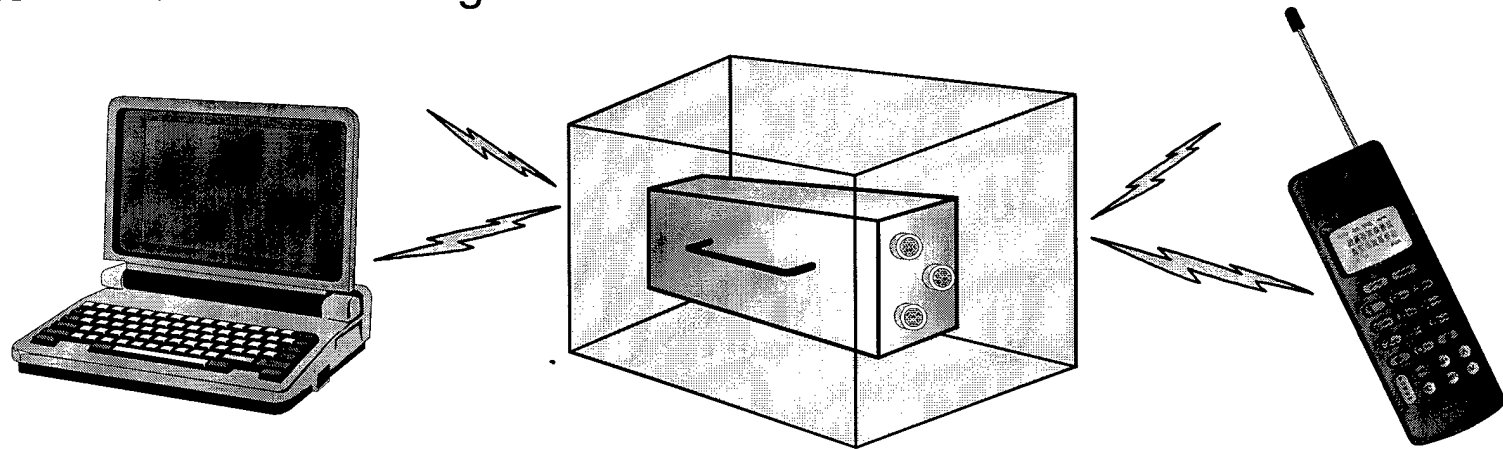
Avionics are Relatively Sensitive to Extremely High Temperatures

Component Shielding

Goal: Resist or Absorb the Damage Mechanisms by Using Coatings or Special Materials

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Example: EMI/EMP Shielding



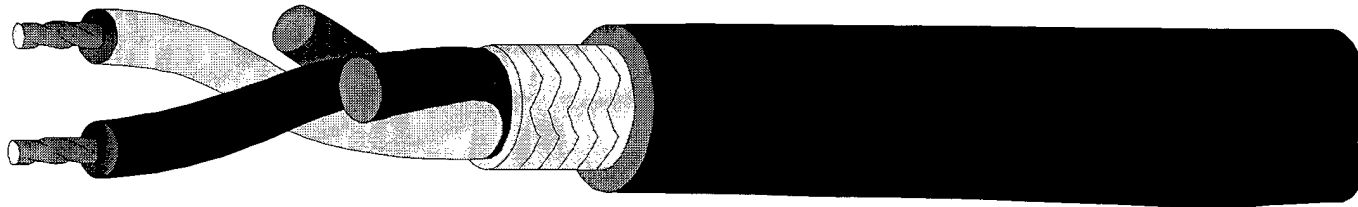
EMI Shielding Most Likely to Be Useful for Civil Aircraft

Component Elimination

Goal: Design Choices That Eliminate a Vulnerable Component or Replace It With Another, Less Vulnerable Component

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Example: Data Bus Cable



Shielded Cables Add Weight, but Are Less Vulnerable to EMI, Blast and Fire

Recommendations:

- Anticipate, Study and Prepare for the Threats
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- Consider Use of Vulnerability Reduction Techniques When Designing:
 - Aircraft Systems
 - Avionics Components
 - Wiring and Cabling
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- Understand That Reliable, Fault Tolerant Avionics May Still Be Vulnerable

Augustine's Law XIV

After the Year 2015, There Will Be No Airplane Crashes.

There Will Be No Take Offs Either, Because Electronics Will
Occupy 100 Percent of Every Airplane's Weight.

Norman R. Augustine